Existence of a Two-Phase Zone at Rapid Solidification of Refractory Oxides and Its Effect on Thermal Radiation Properties

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All existing studies of melting and solidification of refractory oxides and their binary systems are based on the premise that there are two distinct phases, one being only liquid and the other only solid, separated by an interface. However, due to the semitransparency of liquid and solid oxides and high temperatures of the phase change, the internal thermal radiation cannot be ignored. It can lead to the existence of a two-phase zone between the liquid and solid.

As an example, the behaviour of a high temperature pool of melt on a solid refractory oxide after removal of heating laser radiation was studied experimentally and numerically. The experimental study of cooling with two rates about 200 K/s and 2000 K/s and high speed solidification of alumina consisted of the measurement of "effective" brightness temperatures and spectral normal-hemispherical reflectivities at different wavelengths as a functions of time and the wavelength dependence of emitted spectral radiation at the solidification plateau. A mathematical model has been developed for one-dimensional transient conditions that included combined radiation and conduction heat transfer in semitransparent non-scattering liquid and solid, a generalized phase change model with the presence of two-phase zone, supercooling, dependence of thermophysical properties on temperature and thermal radiative properties on temperature and wavelength.

Results of numerical calculations have been applied for analysis of obtained experimental data including the behaviour of measured "effective" temperatures at the solidification plateau and for estimation of true solidification temperatures from the results of "effective" temperature measurements. It is shown for the first time that the temperature plateau, which was observed before at measurements of solidification temperature of some refractory oxides in solar and image furnaces in connection with the problem of secondary temperature standards, is explained by the existence of a two-phase zone. The effect of a two-phase zone on the measurement of thermal radiation properties and temperature of phase change is obtained and analyzed.